Photo: Robert L. Stevenson

Tough Bows and Iron Blades: Modifying the M1 for Urban Battle

by Captain Frank Bridges and Captain (P) Michael R. Evans

Now to bring the tough bow out and bring the iron blades.

Now to try these dogs at archery to usher bloody slaughter in.

Homer, *The Odyssey*

Odysseus went into the final battle of his long homecoming badly outnumbered. He knew that he would have to defeat his enemies quickly and decisively and that a long attritional struggle would result only in his utter defeat, and so he prepared accordingly: he took a bow and iron axes to a fight with men armed only with bronze swords and spears. He had prepared ahead for an unfamiliar and risky tactical environment and modified his equipment accordingly.

Sooner or later, the U.S. Army will fight an urban battle, and tanks will be there. While the M1-series tank is an awesome combat system, it is not optimized for an urban environment. Unmodified tanks will not be fully capable of executing their doctrinal role, if they are not optimally prepared. In the worst-case scenario, an unprepared tank must expend all its energy and the energy of a dedicated infantry element simply avoiding destruction. If tanks are not to be relegated to the role of helpless observers, shepherded by infantry to meet the demands of force protection, then tanks will require some modification to prepare them for this unfamiliar and dangerous environment. This article suggests some ideas for simple, currently available, easy-to-install appliqué systems that will enhance the M1-series tanks' already substantial capabilities for operations on an urban battlefield.

The Urbanization Trend

Current demographic trends point out a simple fact: the world population is increasingly urban. The 20th century appears to have been the last in which a majority of humans lived in nonurban areas.

By 2015, more than 50 percent of the world's population will live in urban areas if this trend continues.[1] Many of these urban areas, unprepared for this scale of growth, are plagued by political instability, poverty, fast growing populations of young men, low rates of employment, breakdown in civil authority, and other ingredients for conflict. As urban areas loom large as potential battlefields, Army armored and mechanized forces face a real challenge. One frequently heard commentary on urban operations bluntly states, "Tanks don't go into cities." This is, however, flatly contradicted by historical review, current doctrine, and common practice. One recent chronicler notes that of 40 major urban battles between 1920 and 1994, 32 were fought with combined arms forces that included tanks and/or other armored vehicles.[2] Tank mobility, firepower, and armor protection are invaluable to infantry in moving through and clearing urban areas. Clearly tanks do go into cities, both historically and in the future, likely for the simple reason that cities are where people are and that is where the battles will be. The degree of success or failure once enjoyed by armor, however, bears some examination.

Combined Arms and the Urban Environment

The key factor to bear in mind is that tanks must always be employed as com-

ponents of a combined arms team in the urban environment. Lone tanks in urban areas are dead tanks. This is nothing new. What is new is the level at which this task organization will occur. The level at which tanks will be task organized on the urban battlefield is situation dependent; however, due to the compartmentalized and restricted nature of the urban environment, it will generally be at a much lower level than that normally applied. This could be a platoon supporting a company, as is generally done in open country warfare, but it could be down as low as individual tanks working with squads.[3] This means that tanks will be "on their own" to a much greater degree than has been common practice in task force or company team operations.[4]

From this starting point, tanks must be regarded critically in terms of their relative strengths and weaknesses in urban areas. Many of the normal strengths of a tank are minimized on the urban battlefield, and many of the weaknesses become serious concerns. Careful consideration and mitigation of these weaknesses will be critical to success or failure on urban battlefields.

Historically, the U.S. Army has viewed the urban battlefield with trepidation and has approached the problem by the simplest method — firepower. U.S. Army Field Manual (FM) 3-06, *Urban Operations*, notes the pervasive trend of U.S. Army WWII experience, "The legacy of Army operations was an effective tactical solution to urban offensive combat: isolate the urban area, seize a foothold, and expand the foothold block by block until occupying the entire urban area and destroying the enemy. The doctrine's emphasis on firepower kept friendly casualties to a minimum. Unfortunately, when enemy forces stoutly defended the urban area, the emphasis on firepower resulted in its virtual destruction and high casualties among noncombatants.[5] This approach is no longer acceptable or even desired. Instead, precise fires, restrictive rules of engagement (ROE), careful force protection, and rapid and decisive operations are the likely hallmarks of future urban battles. Within these restrictions, the tank mission remains essentially unchanged. Tanks are generally employed on the urban battlefield in one of two primary roles — support by fire (SBF) and attack by fire (ABF).

While these tasks are familiar, execution in urban environments is not. One of the most significant aspects of the urban battlefield is the all-around nature of the battlespace. Linear operations will be nearly impossible. Any piece of the urban landscape is subject to enemy reoccupation if it is left unoccupied or is not cordoned off by friendly forces. Without enough troops to occupy every piece of urban landscape, most military forces will move through the urban environment as a fish moves through the sea: passing through it without controlling anything more than the part within their immediate area. Opposing forces may similarly "swim" through this environment and may approach from any direction in three dimension. Combat and service support units must be prepared for enemies that will approach not only from the front or sides, but also from above, below, or behind.

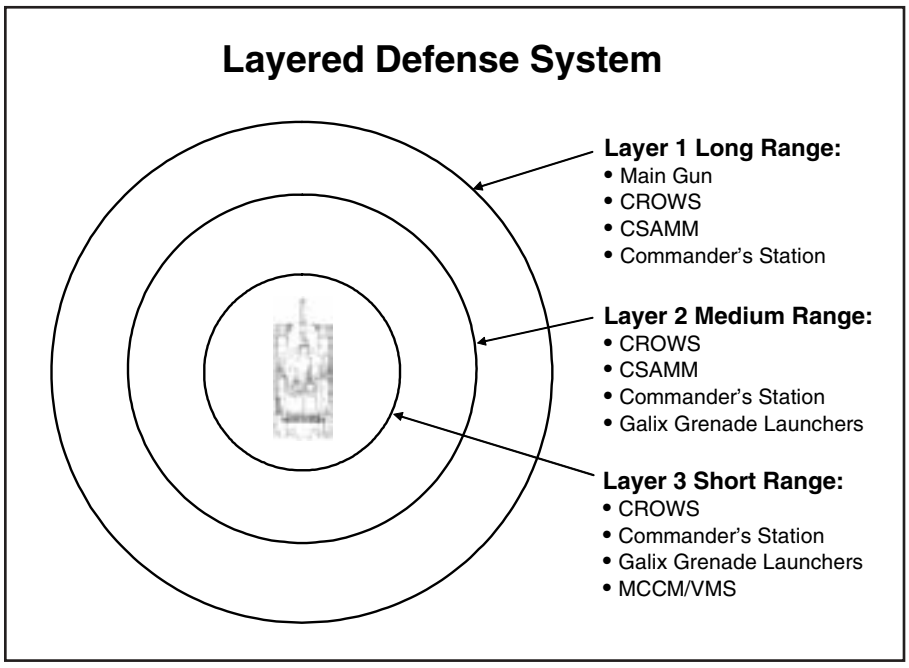

Figure 1. Layered Defense

Tank crews preparing for this battlefield will find they must modify not only their tactics, but also their tanks. U.S. Army tank crews have done so before, in Aachen, Manila, Seoul, and Hue, to name only a few. Their tactical learning curve was matched only by their ingenuity: a review of history shows tanks with additional armor, added machine guns, hastily added external mirrors, exterior storage that doubled as spaced armor, improvised plows, and even directional mines affixed to hulls for close combat.[6]

Future systematized modification is still a subject for speculation, but one thing is certain — we cannot afford to learn on the job through attrition-based warfare; we simply lack the number of forces it would take to fight our potential enemies one-on-one, even if the price in casualties was still acceptable. Further, our historic form of linear operations may no longer be the dominant mode, both from a dearth of friendly forces and assets, as well as in response to threat tactics that make everywhere a front line.[7] The protection, rapid mobility, and precise fires provided by tanks remain a powerful battlefield asset, but there is room for improvement.

Armored vehicles bring to the urban battlefield long-range target acquisition, high volume precise firepower, armor protection, and mobility. The mobility is particularly useful: tanks can move rapidly over rubble and debris to points where, with their protected firepower, they can dominate or isolate areas. This rapid maneuver causes surprise, disorientation, and psychologically dislocates the enemy, which disrupts his plans and will. The union of mobility and protected firepower can benefit other elements, providing fires that can reduce almost any fortification in the face of enemy resistance. Applying these strengths in the urban environment, however, requires careful consideration, for weaknesses accrue as well.[8]

Armored vehicle weaknesses are generally known, but in practice have been mitigated during open country operations by effective tactics and by design practices dictated by the nature of the open battlefield. These weaknesses have been acceptable risks as long as open country warfare is the accepted norm. The urban area, however, turns many of these assumptions on their heads. Key weaknesses that assume importance in the urban area include two of the tank's three main

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features: firepower and protection. Turret/gun traverse length and poor close-range visibility hamper firepower; sacrifices in armor (on the top and rear in particular), coupled with poor visibility, create dangerous vulnerabilities. Clearly, modifications and adaptations that will mitigate these weaknesses will help the M1-series tank transition to an environment that its designers expected to avoid. Modifications should meet several criteria, however. Firepower, mobility, survivability, and the ability to work with the combined arms team should be improved. These improvements should consist of easy-to-install kits that can allow upgrading based on the threat; making maximum use of off-the-shelf components while minimizing modifications to the tank. Finally, the tank's ability to perform its battlefield mission of offensive mounted warfare should not be effected.

Conceptually, the approach to modifying the M1-series tank for urban operations may be seen as a system of zones based around improving visibility and forming a layered defensive armament. Visibility is improved with multiple, redundant acquisition systems against current visibility that is limited to the tunnel vision of the gunner's primary sight/gunner's primary sight extension and to the limited field of view offered by the commander's and driver's vision blocks and the loader's single rotating vision block. Layered defense is formed by "layering" current and new systems into long range, medium range, and short range. Several weapons systems and combinations provide overlapping capabilities for protection of the tank, allowing it to continue in its primary role of mounted maneuver.

Firepower[9]

The firepower of the M1-series tank is almost without peer today, but it was not intended for the urban battlefield. One key limitation is main-gun elevation and depression. M1 tanks are designed with low profiles; accordingly, the interior size of the turret is limited. Within this space, the size and length of the breech limits elevation of the main gun.

Similarly, limits on elevation result in a zone overhead in which the tank cannot fire. This deadspace is particularly dangerous. It offers ideal locations for fires on the tank's most vulnerable areas: the flanks, rear, and top, and from locations to which the tank cannot return fire.

The M1-series tanks' primary weapon is the 120mm main gun. Current M1 main gun ammunition is some of the best in the world, but tank crews are most familiar with armor-piercing, fin-stabilized, discarding sabot (APFSDS) and high-explosive antitank (HEAT) rounds, which are not the best for urban operations. APFSDS rounds are of limited use against non-armored targets such as buildings or bunkers.[10] The multipurpose antitank (MPAT) round (M830A1) and the MPAT obstacle-reducing (MPAT-OR) round (XM908) all have great potential value on the urban battlefield. A further avenue of approach might be to pursue NATO-compatible 120mm ammunition such as the high explosive multipurpose (HEMP) round being developed by Rheinmetall. Any of these rounds give the tank commander what he needs: an expanded range of options for the urban battlefield.[11]

Even with appropriate ammunition, the tank main gun may not be appropriate for all environments, particularly if restrictive ROE are in effect or friendly troops or noncombatants are present. A good example would be counter-sniper engagements. Typical threat tactics might employ a sniper to bait U.S. forces into engaging with heavy weapons fires, in the hopes that U.S. fires would inflict non-combatant casualties or excessive collateral damage that would play into a threat information campaign. The tank's protection and target acquisition capability, however, makes it ideal for the counter-sniper role.

What the tank needs is the ability to engage targets with *limited* precision fires. Mounting an additional .50-caliber M2HB machine gun, on the counter-sniper antimaterial mount (CSAMM) would allow precision point engagements with .50-caliber fires using the tanks' own fire control system (FCS) and sights. Using the CSAMM, the crew can switch easily between main gun and a .50-caliber M2HB mounted coaxially with the main gun.[12] The mount includes a single shot to low-rate-of-fire timer and side mount solenoid to ensure controlled fires on target. The embedded ballistics of the FCS ballistic computer gives the gunner range and accuracy.

A further potential addition to the tank's precision armament is currently in production for the Stryker family of vehicles. The common remotely operated weapon station (CROWS) is a remotely controlled mount and sight that can mount either the M2HB (with 200 rounds) or Mk19 (with 32 rounds). The CROWS could be mounted either on top of the commander's independent thermal viewer (CITV) turret (on the M1A2SEP) or on the CITV mount position for the M1A1. This would allow an additional remotely operated weapon, or it could be used to replace the loader's M240 or the tank commander's .50-caliber machine gun on the M1A2, both of which can only be fired from an open hatch exposed position.[13]

Survivability

The urban environment will be characterized by close-range engagements, especially by enemy antiarmor teams who will approach as close as possible in an attempt to maximize their effects while avoiding the tank's defensive fires. Accordingly, the M1 tank should be able to defend itself from attacks that occur within its deadspace.[14] Adding grenade launchers, such as the Galix system, fire various types of 80mm grenades, including stun, smoke, flare, and tear gas singly or in volleys. The modular crowd control munition (MCCM) paired with the vehicle mounting system (VMS) of-

fers another solution. The M5 MCCM is a nonlethal, rubber-ball filled explosive directional munition housed in a Claymore mine casing (it is identical in size to and interchangeable with the M18 Claymore). It is mounted on vehicle exteriors with the VMS kit. The VMS consists of four mounting brackets, junction box, and a control box that allows single or volley fire of the munitions from inside the vehicle. For nonrestrictive ROE environments, the M5 MCCM can also be exchanged with the M18 Claymore to provide a lethal defense option, which would be a particularly effective defense against short-range antiarmor ambush.

The tank also faces threats from lasers or laser-guided munitions. Laser threats include laser rangefinders, laser illuminators, or laser beam-rider antitank guided missiles (ATGMs). The U.S. superiority in mounted maneuver is well known across the world. Potential threats seeking inexpensive countermeasures against U.S. forces are actively procuring and fielding these systems. In the urban environment, a tank represents not only a component of combat power, but is also a high-payoff target; its size and apparent invulnerability make it a potent symbol. Close-range laser illuminators, coupled with standoff beam-rider ATGMs would be a difficult combination to counteract in the urban battlefield.[15] The U.S. Army has adapted commercial technology to a range of laser warning systems (LWS) for ground vehicles to provide threat detection as well as survivability, situational awareness, and targeting functions. LWS systems can also provide increased lethality through integration with the FCS in the M1A2, cuing independent sensors or slewing the turret or weapon to the threat to provide rapid return or suppressive fires.

Maintaining situational awareness (SA) is one of the greatest challenges for any element on the urban battlefield, but is especially so for tank crews. Operating with closed hatches, the tank crew lacks visibility and is dependent on accompanying infantry and on wingman tanks for much of the information that helps to make up their SA. SA can be greatly enhanced by adding visual devices that reduce or eliminate deadspace. Two methods of vision enhancement are a gimbaled sensor suite mounted on a mast and distributed sensor suites around the vehicle.

A good example is the head tracked sensor suite made by Kaiser. Mounted on an extendable mast, it is a simple "bolt-on" forward-looking infrared (FLIR)/image intensification (I2) and laser designator; the gimbal houses sensors and has a 360-degree field of regard and a 90-degree look-up/look-down capability. When mounted on the bustle rack, it can be extended up to 20 feet above ground, from which vantage point the viewer can see over walls or other obstructions, onto rooftops, into elevated windows, and even peer "down" into depressions. The gimbal can be controlled through a head tracked/helmet mounted display system that can be mounted on the TC's or driver's helmet. The wearer simply looks in the direction and elevation of interest and the gimbal automatically turns to that point, as if the wearer was looking through the "transparent" sides of the tank. Alternately, for the TC for example, the gimbal can be joystick controlled.[16]

Tank crew SA would also benefit from seeing into close-range deadspace, especially to their rear. Linked to the VMS, an enemy's ability to employ deadspace to approach the tank would be almost eliminated. In a typical distributed sensor suite, the sensors are distributed around the vehicle, providing the desired field of view. Several examples of distributed sensors are:

- Primary forward facing sensor module consisting of uncooled FLIR, image intensified charge coupled device (with additive fusion), and 2-day cameras.
- Extended dynamic range day cameras for side view (some capability at dusk, dawn, and full-moon night).
- A rear-facing FLIR with reversed image to eliminate mirror effect from looking backward.

Maintaining SA is vastly simplified if all sensors on the battlefield could be networked together so those who need information could acquire it in near-real time. Adding TEAC's multi-channel mission data recorder (MDR) 80 to the Abrams tank would allow the crew to continually record information from all vehicle sensors. These might include an infrared/I2-fused sensor mounted on an extendable mast, the CITV, or the gunner's sight. In addition, the mission data recorder has provisions for connecting to a wireless network such as the warfighter information network-tactical (WIN-T). This connection allows the information to be shared with any other station on the network. Further, the Abrams crew could reach out and obtain sensor information from other platforms on the network, such as other tanks or fighting vehicles, Stryker vehicles, unmanned aerial vehicles, attack helicopters, and other platforms equipped with compatible systems.[17]

Mobility

A tank's combat power in urban combat is a critical element of the combined arms team. As such, they are an important target for enemy forces. One technique enemy forces may employ is using obstacles or mines to delay, fix, or destroy tanks. They can use this technique to either gain the information value of a destroyed tank or to remove their combat power from the team, thus making the infantry fight a relatively even match. Typical urban obstacles range from elaborately prepared systems to hastily erected systems, or inadvertent blockages that may simply be rubble, debris, or other readily available assets. Significantly, the obstacles are far easier to conceal than in rural areas: drainage pipes packed with high explosives or buildings rigged for demolition to collapse into streets or blow walls and debris out into streets are good examples. Other types may be inadvertent, such as rubble and rebar piles, burning buildings, wrecked vehicles, or cratering caused by the collapse of underground structures. The engineer component of the combined arms team is absolutely critical, the demand for their services in the urban area may, however, be such that the combined arms team will have to make do with their own systems and assets in many cases.

One asset that was once considered essential is the dozer blade. In M60A3 tank platoons, one tank per platoon was equipped with a bulldozer blade for digging platoon battle positions. A bulldozer blade would be similarly effective today, for use in clearing rubble and barriers during urban movement.

Existing mine plow and roller sets are useful in some urban circumstances: the mine plow can effectively clear low loose-rubble or dirt barricades that have been sown with mines; the mine roller is effective in clearing routes that are not hard-surface.[18] On hard surfaces, however, surface-laid mines will remain a problem: plows, rollers, or a dozer blade will be necessary to clear mines, especially in the face of enemy small-arms fire. The commander must be willing to accept damage or destruction of these assets in the event of detonation while "scraping" this obstacle.

Protection

During the battles for Hue and Saigon during the 1968 Tet Offensive, American

armored forces provided decisive combat power that helped to defeat the enemy attack. This victory did not come without cost; armored vehicles were high priority targets for enemy forces, who acted accordingly. American armored units were subjected to numerous short-range antiarmor ambushes and came under massive enemy fires as they maneuvered to assist friendly troops and destroy enemy elements. American armored vehicles were hit again and again by antitank weapons, thrown satchel charges, mines, grenades, and various calibers of automatic weapons and small-arms fire. Many vehicles absorbed massive amounts of damage; some were destroyed. Many that survived continued to fight despite damage that would have consigned a peacetime vehicle to depot-level maintenance.

Cover and concealment in close proximity to canalized avenues of approach will increase the likelihood of close-range ambush. The three-dimensional battlefield will also offer opponents positions from which to attack from above or below. Additional armor outside the frontal arc will help to counter attacks from these relatively vulnerable directions. Generally, additional armor will take the form of reactive or passive panels. Reactive panels are filled with explosives and explode outward when struck by an enemy projectile, disrupting an armor penetrating fragment or jet. Passive panels pre-detonate or disrupt a projectile before impacting the surface below it. Key points are:

- Turret top.
- Along bustle rack (turret rear).
- Engine deck.
- Rear portions of side skirts.
- Rear of hull, including exhaust grill.

Reactive armor only works once per panel and is best employed where there is a relatively low probability of being struck more than once at the same point. Russian T80 tanks in the Battle for Grozny during 1994 and 1995 were equipped with reactive armor but proved vulnerable to the Chechen rebel tactics, which included volley fires of rocket-propelled grenade (RPG)-7 or RPG-18 rounds from overhead positions. Initial rounds would blow off the reactive armor panels, allowing subsequent rounds to penetrate. The Chechens also aimed for TC and driver hatches, knowing that these were particularly vulnerable points.

For the urban area, additional armor must add to the vehicle's extant armor and must, like the vehicle, survive successive hits.[19] The armor should be spaced to reduce penetration and spalling, and should be sloped so as to create glancing impacts that can "dud" incoming rounds or reduce their effectiveness. These can be in the form of kits or they can be locally fabricated.

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Locally fabricated spaced armor has been employed in a number of conflicts, recently by U.S. forces during the Vietnam conflict, by British forces in Northern Ireland, and by Russian forces in Chechnya. Typical materials used include welded metal bars and sheets of chain-link fencing.[20]

Infantry Support

To protect a tank from attackers within its deadspace, infantry must move with the tanks at all times.[21] This is not a support role, but should be regarded as a combined arms team, with the tank and infantry components playing the roles of separate mutually supporting maneuver elements within the larger team. As the infantry protects the tank from close-range attack, so does the tank enable dismounted maneuver by employing its protected firepower to destroy or suppress enemy positions prior to or during infantry assault.

Moving close alongside or behind the tank can be challenging.[22] The tank crew most likely cannot see the infantry and may be completely unaware of their precise location. The infantry may be employing the tank as cover just as the tank crew decides to move out or change position. Further, the extreme heat produced by M1 tank exhaust prevents dismounted infantry from following closely (unless an exhaust deflector is used). The team will generally employ traveling overwatch or bounding overwatch and will likely communicate with hand-arm signals and radio. While the size of the element will vary according to the width of the street, the technique is viable whether the bounds are by individual tanks and dismounted squads, by tank sections and infantry platoons, or by tank platoons and infantry companies.

There are three elements of the tank that could be modified to improve tank-infantry coordination: exhaust deflection, tank-dismounted communications, and target designation.

The exhaust gases of the M1A1 tank turbine engine are extremely hot and are hazardous to troops at close range. In the urban environment, however, troops will work in close proximity to tanks, possibly using the rear or sides of the tank for cover from enemy fire. While the maintenance exhaust deflector works well, the exhaust "elbow" for the deep water fording kit used by the U.S. Marine Corps is more robust and works better.[23]

Infantry working in close proximity to tanks must communicate with the tank

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commanders and crew. With the tank hatches closed, visual signaling is almost impossible, and volumes of traffic in the SA-challenged urban fight often swamp radio communications. Radio communications beyond line of sight may be severely degraded in the urban battle, particularly in the presence of steel-framed multistory structures. One method to improve communications is in development now: the ICOM wireless communication system.[24] Another method is attaching a TA-1 or TA-312 phone to the turret communications panel or wiring an additional intercom hookup.[25]

Infantry laser pointer target designators are invisible to tank crews unless they open their hatches and scan with night vision goggles. The thermal imaging system and CITV sights cannot see the infantry laser pointer; they also cannot see through window glass, a key point when considering both fratricide avoidance and target designation by dismounted troops unfamiliar with tank limitations. A fused image overlays an image-intensification view on a FLIR view, allowing the tank crew to view laser pointer dots using the primary sight. This is critical in urban combat where infantry designation of targets for tank main gun fire will be the norm.

One size does not fit all in the urban environment. Urban areas vary, as will the threat environments and the missions to be performed there. Urban battles will be characterized by what General Krulak called "The Three Block War," in which relief missions, low-intensity conflict, and conventional battles will rage within the same battlespace, separated only by one or a few streets. Task force and brigade combat team commanders must have the tools to tailor their forces to this environment, just as the task forces are tailored organizationally. This process should be demand based and driven not by a checklist but by the informed judgment of the commander, based on his knowledge of the art of war. A kit approach of items or systems that is available now meets this need, reduces risk, adds flexibility and adaptability, and accelerates the acquisition process.

When U.S. tank crews are called on to enter that urban environment, they will have to do so whether they are prepared or not. The training and professionalism with which they approach that problem is a function of their training, organization, and professionalism. It is incumbent on the institutional Army to do the rest to allow them to execute their mission through demanding training, insightful doctrine development, and in rapid, holistic, and carefully considered innovation. Our enemies are adapting quickly to our established and comfortable ways of war; we must change ahead of their learning curve or face the consequences. One thing is certain — we cannot afford to wait until the last minute to search for our tough bows and iron blades.

Notes

[1]National Intelligence Center, *Global Trends 2015*, Central Intelligence Agency, Langley, VA, December 2000, p. 20.

[2]Roger J. Spiller, *Sharp Corners: Urban Operations at Century's End*, U.S. Army Command and General Staff College Press, Fort Leavenworth, KS, study commissioned in 1994, publication undated, appendix: Catalog of Urban Battles. The battles that did not include significant armored vehicles were Warsaw (1920), Nanchang (1927), Canton (1927), Shanghai (1932), Myitkyina (1944), Imphal-Kohima (1944), Santo Domingo (1965), and Port au Prince (1994).

[3]One effective technique employed by the U.S. Marine Corps has been to task organize a tank platoon with a company, broken down as a section each with two of the three infantry platoons. Each tank of the two sections is teamed with one squad; the third (infantry pure) squad forms the exploitation and maneuver element. The squad/tank teams serve as integrated fire/security elements. Two platoons of a company would be task organized in this way; the platoon without tanks would act for the company in the same role as the pure squad does at platoon level.

[4]Canalization and compartmentalization caused by structures and debris will force elements apart and require them to function on their own: a mere 50m separation between two tanks will be far greater in effect for the physical separation caused by 50m of structures, which precludes any supporting fires, line-of-sight communications, and possibly even FM communication. They will be truly on their own.

[5]U.S. Army Field Manual (FM) 3-06, *Urban Operations*, U.S. Government Printing Office (GPO), Washington DC, May 2002, p.1-7.

[6]Many of these techniques are discussed in detail by Ralph Zumbro, *Tank Sergeant*, Presidio Press, Novato, CA, 1986.

[7]Threat tactics may see battles not as conventional struggles to attrite or destroy forces, but rather as "propaganda of the deed" (Nikolai Bakunin), "information warfare" (FM 100-6), or "war as a spectacle" (IDF).

[8]FM 3-06, *Urban Operations*; for more information on demographic trends see the CIA publication *Global Trends 2015*, cited above.

[9]FM 3-06.11, *Combined Arms Operation in Urban Terrain*, U.S. GPO, Washington DC, February 2002, pp. 7-31 thru 7-36.

[10]In the absence of more specialized ammunition, some effective tactics may still allow significant effect if using service Sabot or HEAT ammunition: cracking a concrete bunker or stone wall, for example, could be done with a Sabot round to break the surface, followed by a HEAT round at the same aim point to exploit and widen the hole.

[11]CPT Frank Bridges, and SFC Michael J. Heeter, "Modifications to Enhance the M1A1 Abrams Tank for Urban Operations," briefing presented for the 16th Cavalry Regiment and for demonstration at the U.S. Army Armor Center Armor Conference, May 2002.

The MPAT-G rounds show superior performance in penetrating urban structures, making holes roughly twice the diameter of HEAT round holes and cutting the concrete rebar that HEAT often leaves intact. MPAT-OR rounds detonated inside the structures, another desirable feature. The HEMP round offers better demolition effect on soft or semi-hard structures, a significant feature in the absence of the now defunct 105mm HEP and the 165mm projectile of the discontinued combat engineer vehicle.

[12]Note that the CSAMM sets the M2HB low enough that it does not block the view of the CITV.

[13]As an example of the limited value of the loader's M240 in urban environment, during the recent Urban Combined Arms Experiment (UCAX) at Millennium Dragon 02, USMC tank crews removed the M240 and the mount to improve the traverse of the .50-caliber commander's weapon station (CWS).

[14]Tank crews in Vietnam mounted M-18 Claymore mines to vehicle exteriors with makeshift attachments: duct tape and sandbags (to cushion the hull against spalling) were the most common, with firing devices (clackers) and wire inside, usually at the drivers' position.

[15]While wire-guided ATGM are generally poorly suited to urban engagements, due to obstructions that could break or tangle the wire and due to the generally long arming distances after firing, beam-rider weapons could be emplaced at medium to far ranges and their laser illuminators would only be more efficient at close range.

[16]The authors tried this system in a demonstration by the contractor. When used with head tracking/helmet mounted displays, the gimbaled sensor suite provides

very natural, hands-free operation. Operation of the gimbal can be allocated to any crew position as required. On the downside, since sensors are located in a single unit, it is susceptible to single point failures or damage such as sniper. Operation of the gimbal is limited to a single user, although multiple users can view the image.

[17]The MDR-80 minimizes communications bandwidth use by employing event marks coded into the recording. These can be introduced manually and/or triggered automatically by a predetermined occurrence such as laser ranging or designating a target, weapon firing, or automatic target recognition.

[18]Provided they are not wired together with rebar or integrated with large chunks of concrete or masonry.

[19]Spaced armor to pre-detonate incoming rounds is problematic because it depends on the nature of the projectile. The RPG-7 warhead forms a self-forging fragment at detonation that is effective at up to 18 inches of standoff and will penetrate 11 inches of armor at 0-degrees incidence. The RPG warhead is delicate, however, and chain-link type material will "dud" the round up to 50 percent of the time by damaging the nose cone firing circuit as the nose fuse passes through the space in the chain links.

[20]The bar stock is spaced to allow passage of the RPG-7 warhead nose while crushing the 66mm projectile sides.

[21]FM 3-06, p. 4-7.

[22]FM 3-06.11, p. C14. Moving in front of the tank could be worse. The muzzle blast of the M256 cannon will kill or seriously injure unprotected persons within a 90-degree frontal arc of the muzzle out to 200m. Beyond that, to a range of 1000m, the discarding sabot petals of APFSDS or MPAT projectiles can kill unprotected persons as well.

[23]In observation of both types of exhaust deflector during urban exercises, the deep water fording kit elbow is more resistant to damage. Further, the maintenance exhaust deflector is made of sheet steel and deteriorates rapidly due to corrosion and exposure to high heat: once warped or bent, it frequently drops off the tank. Finally, the elbow can be set at angles, including upside down: not only does this deflect the exhaust plume down (and away from troops overhead or on the tank deck) it can also be directed into manholes to induce enemy troops to abandon underground positions. The NSN of the Fording Kit, Deep Water is 2540-01-300-6502.

[24]Tested by the U.S. Marine Corps during Exercise Millennium Dragon 02, the ICOM is a multichannel, nonsecure, handheld, commercial off-the-shelf radio, similar to popular commercial family radios. They can be fitted with an earpiece and voice activated microphone.

[25]CPT William Carter and Mr. Jack Jory, "Appendix C, Ground to Tank Communications," Center for Army Lessons Learned (CALL) Newsletter 98-10, Center for Army Lessons Learned, Fort Leavenworth, KS. This system can be installed by organizational maintenance and employs a C-2296 VRC intercom control unit mounted externally and connected via a cable routed from the drivers' position along the floor of the hull. This system meets the requirements of Army Regulation 750-1, *Army Materiel Maintenance Policy and Retail Maintenance Operations,* Modification Work Orders (MWOs), paragraph 4-9f.

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